What do we learn from Schumpeterian growth theory?

Aghion, Akcigit, & Howitt (*Handbook of Economic Growth* 2014)

Levi Crews (Chicago)

January 2020

What is Schumpeterian growth theory?

- **creative destruction**: process by which new innovations replace older technologies
- **Schumpeterian growth theory**:
  - models of creative destruction
  - rich micro data
- **characterized by competing externalities**:
  - knowledge spillover effect: any new innovation raises productivity forever ("standing on the shoulders of giants")
  - business stealing effect: any new innovation destroys the rents of the previous innovator

Basic model: One product line à la Aghion & Howitt (1992)

- **Household**: mass L infinitely-lived, $U(C) \propto C$, discount rate ρ, supply labor to production or R&D
- **Production**: final good (numeraire) and intermediate good (one line)
  - final: competitive, $Y_t = A_t y_t^\alpha$
  - intermediate: Bertrand, $y_t = \ell_t$, but no notion of firm
- **Innovation**: with frontier quality A, new innovation is quality γA $(\gamma > 1)$ $\implies$ **creative destruction**
- **R&D**: z_t units labor $\implies$ new innovation arrives at rate λz_t

- **in-class**: final goods used in intermediates production and R&D; labor only used in final goods
- **in-class**: continuum of product lines, unit-elastic demand for each
- **Handbook**: step-by-step (effects of competition)
- **Handbook**: firm = collection of product lines (firm dynamics)

Basic model: One product line à la Aghion & Howitt (1992)

- **Household**: mass L infinitely-lived, $U(C) \propto C$, discount rate ρ, supply labor to production or R&D
- **Production**: final good (numeraire) and intermediate good (one line)
  - final: competitive, $Y_t = A_t y_t^{\alpha}$
  - intermediate: Bertrand, $y_t = \ell_t$, but no notion of firm
- **Innovation**: with frontier quality A, new innovation is quality γA $(\gamma > 1)$ $\implies$ **creative destruction**
- **R&D**: z_t units labor $\implies$ new innovation arrives at rate λz_t

- **in-class**: final goods used in intermediates production and R&D; labor only used in final goods
- **in-class**: continuum of product lines, unit-elastic demand for each
- **Handbook**: step-by-step (effects of competition)
- **Handbook**: firm = collection of product lines (firm dynamics)

Basic model: One product line à la Aghion & Howitt (1992)

- **Household**: mass L infinitely-lived, $U(C) \propto C$, discount rate ρ, supply labor to production or R&D
- **Production**: final good (numeraire) and intermediate good (one line)
  - final: competitive, $Y_t = A_t y_t^{\alpha}$
  - intermediate: Bertrand, $y_t = \ell_t$, but no notion of firm
- **Innovation**: with frontier quality A, new innovation is quality γA ($\gamma > 1$) $\Longrightarrow$ **creative destruction**
- **R&D**: z_t units labor $\Longrightarrow$ new innovation arrives at rate λz_t

- **in-class**: final goods used in intermediates production and R&D; labor only used in final goods
- **in-class**: continuum of product lines, unit-elastic demand for each
- **Handbook**: step-by-step (effects of competition)
- **Handbook**: firm = collection of product lines (firm dynamics)

Basic model: One product line à la Aghion & Howitt (1992)

- **Household**: mass L infinitely-lived, $U(C) \propto C$, discount rate ρ, supply labor to production or R&D
- **Production**: final good (numeraire) and intermediate good (one line)
  - final: competitive, $Y_t = A_t y_t^\alpha$
  - intermediate: Bertrand, $y_t = \ell_t$, but no notion of firm
- **Innovation**: with frontier quality A, new innovation is quality γA $(\gamma > 1)$ $\implies$ **creative destruction**
- **R&D**: z_t units labor $\implies$ new innovation arrives at rate λz_t

- **in-class**: final goods used in intermediates production and R&D; labor only used in final goods
- **in-class**: continuum of product lines, unit-elastic demand for each
- **Handbook**: step-by-step (effects of competition)
- **Handbook**: firm = collection of product lines (firm dynamics)

Basic model: One product line à la Aghion & Howitt (1992)

- **Household**: mass L infinitely-lived, $U(C) \propto C$, discount rate ρ, supply labor to production or R&D
- **Production**: final good (numeraire) and intermediate good (one line)
  - final: competitive, $Y_t = A_t y_t^{\alpha}$
  - intermediate: Bertrand, $y_t = \ell_t$, but no notion of firm
- **Innovation**: with frontier quality A, new innovation is quality γA ($\gamma > 1$) $\implies$ **creative destruction**
- **R&D**: z_t units labor $\implies$ new innovation arrives at rate λz_t

- **in-class**: final goods used in intermediates production and R&D; labor only used in final goods
- **in-class**: continuum of product lines, unit-elastic demand for each
- **Handbook**: step-by-step (effects of competition)
- **Handbook**: firm = collection of product lines (firm dynamics)

Balanced growth equilibrium: Two equations

BG equilibrium: constant y and z;

$X_{k+1} = \gamma X_k$ for any agg. var. X

1. **Labor market clearing**:

$$L = y + z$$

2 **Research-arbitrage**: equate returns to unit of labor over dt

$$\underbrace{w_k}_{\text{wage after } k \text{ steps}} = \lambda \underbrace{V_{k+1}}_{\substack{\text{NPV of making} \\ (k+1)\text{th step}}}$$

Balanced growth equilibrium: Two equations

BG equilibrium: constant y and z;

$X_{k+1} = \gamma X_k$ for any agg. var. X

1. **Labor market clearing**:

$$L = y + z$$

2 **Research-arbitrage**: equate returns to unit of labor over dt

$$\underbrace{w_k}_{\text{wage after } k \text{ steps}} = \lambda \underbrace{V_{k+1}}_{\substack{\text{NPV of making} \\ (k+1)\text{th step}}}$$

Value of innovation:

$$\rho V_{k+1} = \pi_{k+1} - \lambda z V_{k+1}$$

$$\boxed{V_{k+1} = \frac{\pi_{k+1}}{\rho + \lambda z}}$$

Balanced growth equilibrium: Two equations

BG equilibrium: constant y and z;

$X_{k+1} = \gamma X_k$ for any agg. var. X

1. **Labor market clearing**:

$$L = y + z$$

2 **Research-arbitrage**: equate returns to unit of labor over dt

$$\underbrace{w_k}_{\text{wage after } k \text{ steps}} = \lambda \underbrace{\frac{\pi_{k+1}}{\rho + \lambda z}}_{\substack{\text{NPV of making} \\ (k+1)\text{th step}}}$$

Balanced growth equilibrium: Two equations

BG equilibrium: constant y and z;
$X_{k+1} = \gamma X_k$ for any agg. var. X

1. **Labor market clearing**:

$$L = y + z$$

2 **Research-arbitrage**: equate returns to unit of labor over dt

$$\underbrace{w_k}_{\text{wage after } k \text{ steps}} = \lambda \underbrace{\frac{\pi_{k+1}}{\rho + \lambda z}}_{\substack{\text{NPV of making} \\ (k+1)\text{th step}}}$$

Equilibrium profits:

- inverse demand curve:

$$p_k(y) = \frac{\partial \left(A_k y^\alpha\right)}{\partial y} = A_k \alpha y^{\alpha - 1}$$

- profit max $\to$ constant markup

$$\pi_k = \max_y \{p_k(y)y - w_k y\}$$

$$\implies p_k = \frac{w_k}{\alpha}$$

$$\implies \boxed{\pi_k = \left(\frac{1-\alpha}{\alpha}\right) w_k y}$$

Balanced growth equilibrium: Two equations

BG equilibrium: constant y and z;
$X_{k+1} = \gamma X_k$ for any agg. var. X

1. **Labor market clearing**:

$$L = y + z$$

2 **Research-arbitrage**: equate returns to unit of labor over dt

$$\underbrace{w_k}_{\text{wage after } k \text{ steps}} = \underbrace{\lambda \left(\frac{1-\alpha}{\alpha} \right) \frac{w_{k+1} y}{\rho + \lambda z}}_{\substack{\text{NPV of making} \\ (k+1)\text{th step}}}$$

Balanced growth equilibrium: Two equations

BG equilibrium: constant y and z;

$X_{k+1} = \gamma X_k$ for any agg. var. X

1. **Labor market clearing**:

$$L = y + z$$

2 **Research-arbitrage**: equate returns to unit of labor over dt

$$\underbrace{w_k}_{\text{wage after } k \text{ steps}} = \underbrace{\lambda \left(\frac{1-\alpha}{\alpha} \right) \frac{w_{k+1} y}{\rho + \lambda z}}_{\substack{\text{NPV of making} \\ (k+1)\text{th step}}}$$

Solve for equilibrium z:

- use (1), (2), and $w_{k+1} = \gamma w_k$
- equilibrium share of labor in R&D:

$$\boxed{z = \frac{\frac{1-\alpha}{\alpha}\gamma L - \frac{\rho}{\lambda}}{1 + \frac{1-\alpha}{\alpha}\gamma}}$$

- positive R&D if $\left(\frac{1-\alpha}{\alpha}\right)\gamma L > \frac{\rho}{\lambda}$

Equilibrium expected growth

- **Recall**:
  - in interval $[t, t+dt]$: successful innovation w.p. $\lambda z dt$
  - $Y_{k+1} = \gamma Y_k$
- **So**: expected log output is

$$\mathbb{E}\left[\ln Y_{t+dt}\right] = \lambda z dt \ln(\gamma Y_t) + (1 - \lambda z dt) \ln Y_t$$

- **Expected growth rate**:

$$\boxed{\mathbb{E}[g_t] = \lim_{dt \to 0} \frac{\ln Y_{t+dt} - \ln Y_t}{dt} = \lambda z \ln \gamma}$$

Comparative statics

Share of labor in R&D:

$$\boxed{z = \frac{\frac{1-\alpha}{\alpha}\gamma L - \frac{\rho}{\lambda}}{1 + \frac{1-\alpha}{\alpha}\gamma}}$$

Expected growth rate:

$$\boxed{\mathbb{E}[g_t] = \lambda z \ln \gamma}$$

R&D and growth are increasing in . . .

- λ: productivity of R&D tech.
- γ: step size of innovation
- L: population (scale effect)

R&D and growth are decreasing in . . .

- α: elasticity of demand
- ρ: discount rate